ASSESSING EXURBAN RESIDENTIAL MARKET: AN AGENT-BASED MODEL

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ABSTRACT

Many of the traditional models used by urban planners are not well-tailored to the exurban residential market. Recent literature recommends that people's preferences on natural amenities, density (neighbor avoidance/large lot), and accessibility play important roles in shaping the exurban residential market. In this research, I explore the use of an agent-based approach to investigate and examine how exurban residential location patterns may result from the behaviors of decentralized and heterogeneous individual households that reflect their preferences influenced by these three drivers of exurban development. Three agent-based models are constructed to detect the dynamic exurban sprawl influenced by the three drivers, one at a time. Simulation results suggest that the agent-based models built in this research have a potential to represent the exurban residential market at a reasonably high level of accuracy.

Keywords: Exurban development, agent-based model

INTRODUCTION

Computer models of urban growth have a long history. Yet many of the traditional approaches used by urban modelers are not well-adapted to exurban environments. Most of these models assumed that households have similar location preferences — close to work (Alonso 1964) — while recent literature recommends that people's preferences for natural amenities, density (neighbor avoidance/large lot), and accessibility play important roles in shaping the exurban residential market (Davis et al. 1994; Nelson 1992; Riebsame et al. 1992; Irwin 1998). Agent-based modeling (ABM) can be used to represent the behaviors of heterogeneous homeowners and the evolution of every individual parcel at a relatively high level of complexity by using a process-based approach. Furthermore, ABM provides a means to assess temporal, decentralized, and autonomous exurban residential development decision making at the household level and link these decisions to aggregate exurban land use changes (Parker et al. 2003).

In this research, I explore the use of an agent-based approach to examine exurban residential location and to investigate how exurban development patterns may emerge from the behaviors of decentralized and heterogeneous individual households, reflecting their preferences influenced by the three drivers of exurban development. Three agent-based models are

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constructed to detect the dynamic exurban sprawl influenced by different location preferences on accessibility, amenities, and density (neighbor avoidance, large lot development).

BUILDING AN AGENT-BASED MODEL

In this research, I formulate two types of agents to represent two types of households searching for exurban residential locations: commuters and second-home owners. Commuters are the traditional type of households in conventional urban models who value a short commuting distance to work most. Second-home owners or amenity-seekers reflect nontraditional types of households found in exurban areas whose location choices are strongly influenced by density level and site amenities (e.g., the presence of open space or a stream, large lots).

I build three theoretical models by using Repast, an ABM platform based on Java, and I explore household land conversion rules according to three types of location preferences (Table 1). Beginning with a model including only one type of household with a preference for urban accessibility only, I add the second type of household — second-home owners – favoring amenities and density in the second and third model, respectively. I examine the effects of accessibility, amenities, and density one at a time.

TABLE 1 Locational preferences by different types of households

Locational Preference Priority	Second-home Owners	Commuters
First	Proximity to natural amenities (public land, lakes, or streams)	Accessibility (proximity to jobs or highways)
Second	Density (quiet environment or large lot)	Density (high level of development in the neighborhood)
Third	Accessibility (proximity to roads or shopping)	Proximity to natural amenities (open space, lakes, or streams)

Agent-based models are built in three phases:

- Model I Assess the effects of accessibility on location.
- Model II Assess the effects of amenities on location.
- Model III Assess the dynamic effects of density/lot size preferences on location. Second-home owners are assumed to be space sensitive; they like a large lot. Commuters are space-neutral.

The first and the second model are designed to detect the static effects of accessibility and natural amenities, respectively. The third model simulates dynamic effects of density with respect to location. These three models are built on an abstract grid. It is a two-dimensional array of regular spaces represented as a mosaic of grid cells. An ASCII file is created and imported to Arcview to create the abstract grid. It has 150 × 150 cells, with a resolution of 100 × 100 meters per grid cell, as shown in Figure 1. This grid is the initial state of the development (i.e., the development at time step 0). All three models will be simulated on the basis of on this abstract grid. Road network, two rural places, public owned lands, a lake, and some streams are drawn randomly and added to the grid. This grid also sets up the basis for calculating accessibility, justify amenities and density variables. One household moves in to the environment/the abstract grid at each time step. Each time step or iteration in a Repast model can be any time period it takes for the next development activity taking place.

The geographic information system (GIS) plays a role in data compiling, processing, and spatial database building. The multi-agent-based modeling tool Repast simulates the temporal and spatial land conversion from one state (undeveloped) to another (developed) according to a set of predefined transitional rules based on households' preferences for accessibility, amenities, and density.

RESULTS AND DISCUSSION

In each of the Model I, II, and III runs, households' preferences and behaviors are adjusted in accordance with the purpose of the model. Commuters and second-home owners enter the environment (the abstract lattice) and interact with it. One household takes up one site or cell in each time step (iteration) depending on the bid it offered according to its location preferences and the result of the bid.

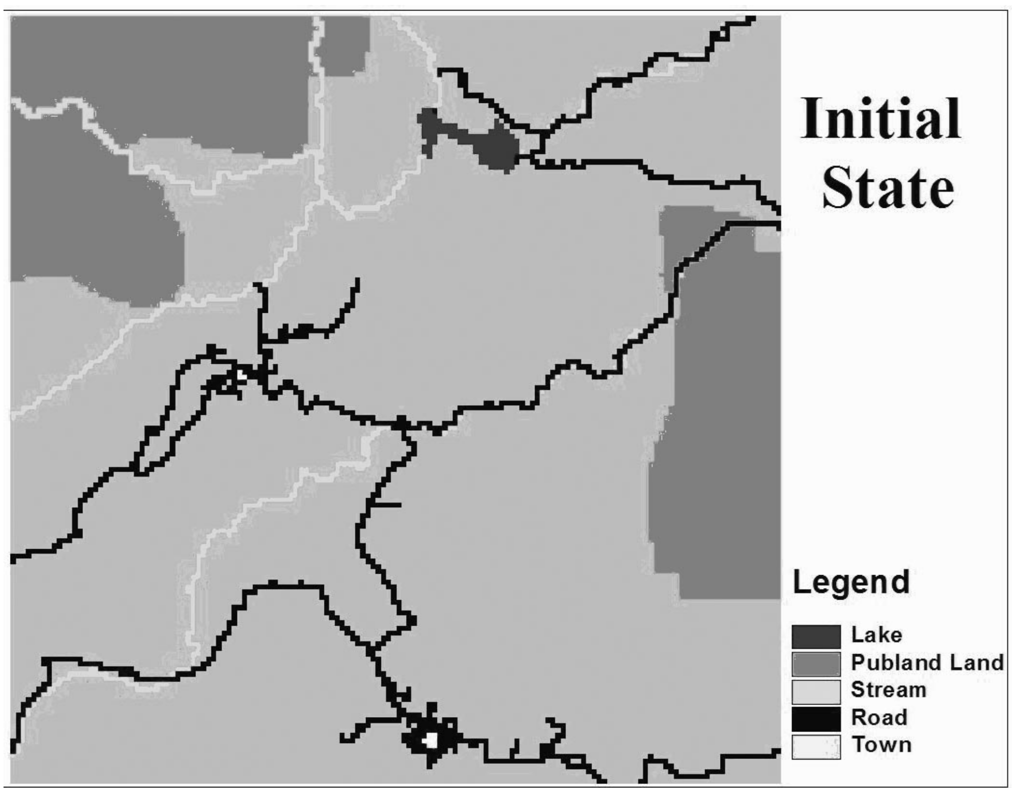

FIGURE 1 Initial state

Model I

Model I results show that build-out first occurs in the areas around the rural places/employment centers where accessibility is considered the highest and then extends to the areas along the transportation corridors. Since commuters favor accessibility factors, all the development gets pulled toward the areas with a high level of accessibility.

Model II

In Model II, because second-home owners chose to develop places in close proximity to natural amenities and commuters chose sites with good accessibility, clusters emerged along transportation corridors and around job centers, as well as in the areas with rich natural amenities (i.e., lakes and public land) or with easy access to both road and natural amenities.

Model III

Model III results show that at the early stage when there are a large number of empty places, second-home owners can find various sites or cells that satisfy their needs to a great extent. They tend to offer higher bids and win their bids more often. Therefore, development patterns are scattered as a result of second-home owners' bid triumph. After some time, development is seen in two extremes: clustering on cities and roads, and dispersion with some tendency to be close to roads. However, there are still more cells developed by commuters than by second-home owners.

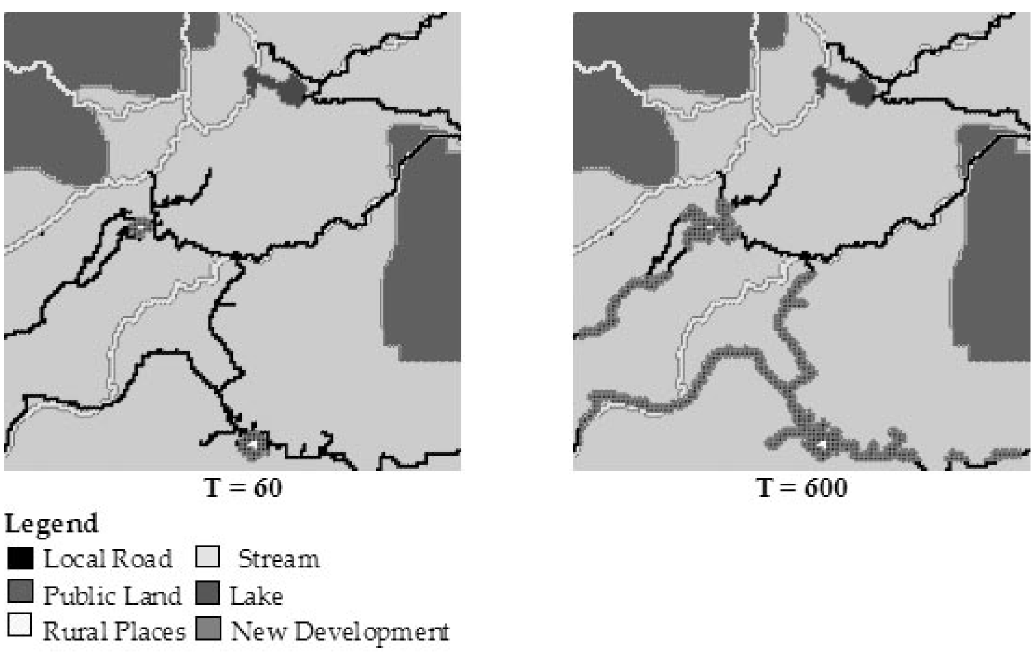

FIGURE 2 Model I

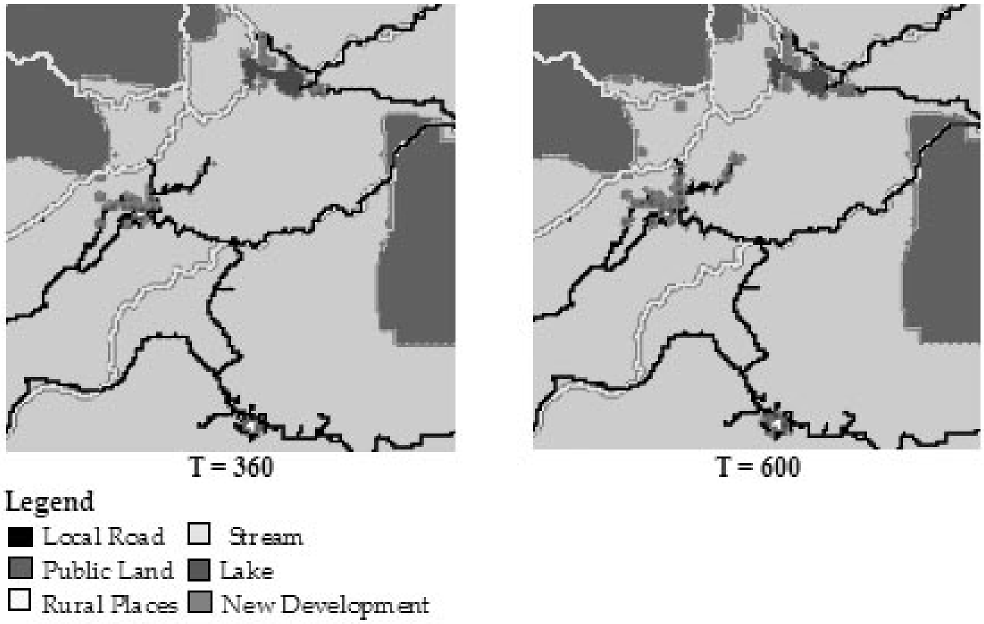

FIGURE 3 Model II

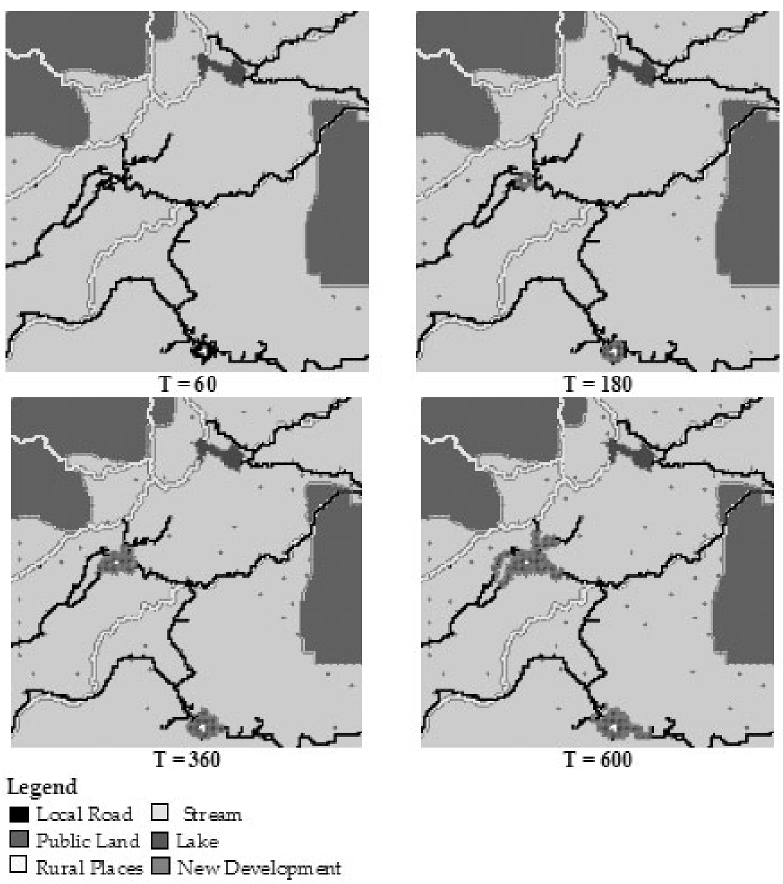

FIGURE 4 Model III

When development gets more and more densified and when accessibility clusters are stretching out, second-home owners find fewer and fewer cells that suit their needs, while commuters still find many sites that highly satisfy their needs. Some time after scattered development is pushed into the areas away from roads because of lack of space for second-home owners, large clusters emerge around areas with good accessibility. This is because commuters win bids more often now.

SUMMARY AND CONCLUSIONS

Model I illustrates how clusters emerged around the urban places/employment centers and along the transportation corridors because of households' preferences for accessibility. However, when compared with the actual development pattern, it concentrates development too tightly around rural places and transportation networks. In Model II, growth goes into areas with either rich amenities or easy access to highways and jobs, reflecting the attractiveness of sites with the presence of public lands or water bodies to second-home owners or of sites in close proximity to existing urban services and accessibility to major highways to commuters. The mix of preferences for amenities and accessibility from different types of households makes the model a more accurate predictor of exurban development than models based exclusively on accessibility for only one household type. However, in comparison with the actual development pattern, development tends to be too tightly around natural amenities.

Model III illustrates two extremes of development density patterns: cluster and dispersion resulting from different household locational preferences. Commuters' preferences for the limited available areas with close proximity to work and transportation networks fuel higher-density development in lands surrounding cities and highways; behavior preferences of second-home owners for large lots, spacious and isolated spaces, and neighbor avoidance push developments into the wilderness, which may become seeds for later development. Model III indicates that patterns of exurban growth density are influenced by factors such as spacing of lots and distance from infrastructure. Households interact with each other in exurban locational decision making. Second-home owners skip over properties close to other developed sites and obtain bigger isolated lots further out. This creates pressure for low-density development and a persistent dispersion pattern, and a significant and disproportionate reduction in the average density of development at the aggregate level. Model III also demonstrates development phasing effects at which exurban development shifts from a land market dominated by second-home owners to commuters. Yet the switch occurs only gradually after second-home owners reach the density threshold.

The agent-based models built in this research help researchers understand how exurban residential location patterns may result from decentralized and heterogeneous individual households' preferences for natural amenities, low density, and accessibility. Simulation results suggest that these models have the potential to represent the exurban residential market at a reasonably high level of accuracy.

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